USING HEURISTICS for Supportability Analysis of Adaptive Weapon Systems in Combat

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The new U.S. Army vision contends that heuristics are practical tools for achieving innovation. Overcoming complex terrain and adaptive hybrid threats in Syria, Iraq, and Afghanistan requires technological innovation. Supportability issues result from modifying deployed weapon systems with new technology for countering these types of threats. Collecting detailed data on deployed weapon systems is constrained in combat zones. A solution for modeling supportability requirements of adaptive weapon systems in a constrained data environment involves heuristics. This modeling effort is achieved by modifying a decision matrix to include heuristics as an alternative field data source.

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Image designed by Diane Fleischer

Complex terrain and hybrid threats in Syria, Iraq, and Afghanistan are indicative of the United States' future warfare challenges and need for adaptable and innovative weapon systems. In regard to innovation, the new *Army Vision* calls for the ability "to rapidly identify and grapple with complex problems and develop heuristics, or rules of thumb, to adapt and achieve results" (Department of the Army, 2015, p. 8).

Hybrid threats adapt their tactics to counter U.S. conventional military strengths, especially weapon systems such as tanks and infantry carriers. Deployed weapon systems can encounter supportability issues after being modified with new technology that is designed to overcome a hybrid threat. These supportability issues usually include degraded reliability, availability, and maintainability (RAM). However, the hazardous nature of combat zones constrains the collection of detailed sustainment data on modified weapon systems, which can limit effective supportability planning. Thus, decision analysis techniques capable of utilizing alternative and limited data sources are necessary.

A heuristic rule of thumb, educated guess, or trial-and-error result is a useful alternative data source for combat situations where experienced-based, after-action report information is often sufficient for immediate problem solving. Furthermore, a decision matrix correlates and weighs different factors to support decision making, and this analytical technique can be modified to use heuristic-based factors.

Integrating Heuristics into Decision Analysis

This investigation used Figure 1's decision matrix configuration as a starting point. This particular matrix example outlines an analysis for determining the engineering design priorities for a compact disk jewel case. The central portion of the matrix contains relationship strength values between factors located on the left and to the top. The customer's requirements and their importance rating are placed to the left. Data-driven technical characteristics needed to meet the customer's requirements are placed at the top. The absolute and relative weighting of the relationship matrix values are placed at the bottom. The value weighting and rank ordering identify which technical characteristics best fulfill the customer's requirements.

FIGURE 1. DECISION MATRIX EXAMPLE FOR DESIGNING A COMPACT DISK JEWEL CASE

Improvement Direction		↓	↓	**n/a**	↑	**n/a**	**n/a**
	Units	**lbs**	**in**	**n/a**	**ksi$\sqrt{in}$**	**n/a**	**n/a**
Customer Requirements	Importance weight factor	Force to open	External dimensions	CD positioning feature in case	Toughness of case material	Hinge design	Shape of case
Cost	5		9	3	9	9	
Crack-resistant	5	3	3	3	3	1	3
Ease of stacking	5	3	3			1	
Ease of removing liner notes	5		3				1
Ease of removing CD	4	3	3	9		1	3
Made of recyclable materials	4				9		
Ease of opening case	4	9	3	1		3	3
Scratch resistance	4		1		3		
Hinge stays together	4	3	3			9	3
Waterproof	4	3			3	1	
	Raw Score	102	130	70	120	111	56
	Relative Weight %	17.3	22.1	11.9	20.4	18.8	9.5
	Rank Order	4	1	5	2	3	6

Source: Deiter & Schmidt, 2009, p. 105
Note. The Importance Weight Factor is scaled from 1 to 5, with 1 referring to least important and 5 referring to most important. The central portion of the matrix uses relationship strength values of 9 for strong, 3 for medium, and 1 for weak. Relationship strength values are multiplied by the Importance Weight Factor, and each column is summed to calculate a raw score.

In a limited data situation, a decision matrix with alternative data types, such as the *Army Vision* recommended heuristics, can assist the analysis of supportability issues for an adaptive weapon system baseline. The Army's Stryker vehicle experience in Iraq—documented by Paul Alfieri and Donald McKeon (2008)—presents this type of analysis opportunity.

The Stryker vehicle experienced several baseline changes while deployed initially to Iraq in 2003–2004 to combat an adaptive threat. The deployed vehicle's new technology insertions and extended operations over complex terrain resulted in significant operational suitability issues—such as degraded RAM and increased sustainment costs (Alfieri & McKeon, 2008). Additionally, detailed sustainment data collection was constrained by combat conditions where "recording and reporting data is not a high priority for operational crews" (Alfieri & McKeon, 2008, p. 60).

For this investigation's decision matrix, the customer requirement is structured for maximizing supportability, and it includes the U.S. Army's baseline reliability and availability requirements for the Stryker vehicle. A maintainability requirement was not available from the Stryker program office. Since Stryker data collection was limited in its combat zone, heuristics are placed at the top to represent the environmental and operational use factors affecting supportability.

Table 1's heuristics model the Stryker vehicle's actual supportability expectations in its Iraq operating environment. Specifically, the heuristics are presented as answers to questions about complex terrain and hybrid threats. These questions are based on a widely used U.S. military information format known as the 5W report: Who, What, Where, Why, and When.

TABLE 1. HEURISTICS FOR DEPLOYING STRYKER FORCES AGAINST AN ADAPTIVE HYBRID THREAT	
5Ws	**Heuristic**
Who	Who is deploying to the complex operating environment to fight against an adaptive hybrid threat? Answer: Army Force Generation deployment models are built around the Brigade Combat Team (BCT) force structure. Likewise, this investigation's data set focused on Stryker BCT operations.
What	What kind of Area of Operation (AO) is the Stryker BCT deploying into (and what are its ramifications)? Answer: Higher operational tempo due to an increasingly expanding AO. Note: Work is force applied over a distance, so having more land area to patrol requires more work over time, which directly relates to system usage.
Where	Where will the Stryker BCT conduct operations in terms of terrain? Answer: Primarily operating in complex terrain and urban environments.
Why	Why does the Stryker BCT have to modify its ground combat vehicle system baseline? Answer: Rapid technology insertion to counter an adaptive threat.
When	When will the Stryker BCT conduct operations (i.e., length of deployment and its ramifications)? Answer: Sustainment of adaptive combat vehicle systems during deployments that are far longer than the original Stryker vehicle Objective Requirements Document requirement.

The matrix vertical columns include an Importance (or Weighting) Factor representing the hierarchy of acquisition requirements (i.e., key performance parameters [KPP], key system attributes [KSA], and objective and threshold requirements). An Importance Factor scale of 1, 2, 3, and 4 was assigned for objective, threshold, KSA, and KPP requirements respectively (Wasek, 2005, p. 77). The matrix configuration modified for heuristics and ready for the input of relationship strength values is presented in Figure 2.

FIGURE 2. DECISION MATRIX MODIFIED FOR HEURISTICS AND MAXIMIZING SUPPORTABILITY

		Importance Factor	Higher OPTEMPO due to an increasingly expanding AO	Primarily operating in complex terrain and urban environments	Rapid technology insertion to counter an adaptive threat	Sustainment of adaptive combat vehicle systems during deployments that are longer than the original requirement
Maximize Supportability	Maximize Reliability Reliability Metric = ?					
	Maximize Availability Availability Metric = ?					
	Absolute Weighting					
	Relative Weighting %					
	Rank Order					

Note. The "Who" heuristic is not needed in this figure since the matrix is specific to a weapon system and not the identity of a military unit. OPTEMPO = operations tempo.

Stryker Supportability Analysis

A number value is inputted into each central matrix cell to assess the relationship strength between the U.S. Army's requirements for maximizing supportability and the heuristics associated with the Iraq operating environment. Various value numbering schemes appear in decision matrix literature, and this investigation used the same 9 (strong), 3 (medium), and 1 (weak) scheme outlined in Figure 1 (Deiter & Schmidt, 2009, p. 103). Across each row, the Importance Factor is multiplied by each relationship strength value, and the resulting column values are summed to determine an absolute weight for each heuristic's effect on maximizing supportability. Rank ordering the relative percentile weights identifies the priority of effort for improving supportability.

Adaptive weapon systems usually include Contractor Logistics Support (CLS), and the contract structure normally incentivizes CLS to exceed the KPP Operational Readiness Rate. Though this process generates higher sustainment costs, supplemental funding is usually programmed to support the sustainment needs of contingency deployments. Accordingly, the strongest relationship (9) exists between maximizing availability and the sustainment of adaptive combat vehicle systems during deployments that are longer than the original requirement.

Conversely, weak (1) relationships exist among increased reliability, increased availability, higher operations tempo (OPTEMPO), and complex terrain, since those factors tend to work against one another. Rapid technology insertion has both positive and negative qualities, hence a medium (3) relationship. The positive aspect involves the use of rapid technology insertion to improve the operational effectiveness, suitability, and survivability of weapon system components (e.g., new armor, fire control, power plant, etc.). However, rapid technology insertion tends to decrease a weapon system's overall reliability due to early failures of the newly inserted components (i.e., the first phase of the reliability bathtub curve). Figure 3 presents the completed decision matrix.

FIGURE 3. COMPLETED DECISION MATRIX FOR STRYKER SUPPORTABILITY

		Importance Factor	Higher OPTEMPO due to an increasingly expanding AO	Primarily operating in complex terrain and urban environments	Rapid technology insertion to counter an adaptive threat	Sustainment of adaptive combat vehicle systems during deployments that are longer than the original requirement
Maximize Supportability	Maximize Reliability (KSA) Reliability Metric = 1000 MMBCF	3	1	1	3	1
	Maximize Availability (KPP) Availability Metric ≥ 90% ORR	4	1	1	3	9
	Absolute Weight		7	7	21	39
	Relative Weight (%)		9.46%	9.46%	28.38%	52.70%
	Rank Order		3	3	2	1

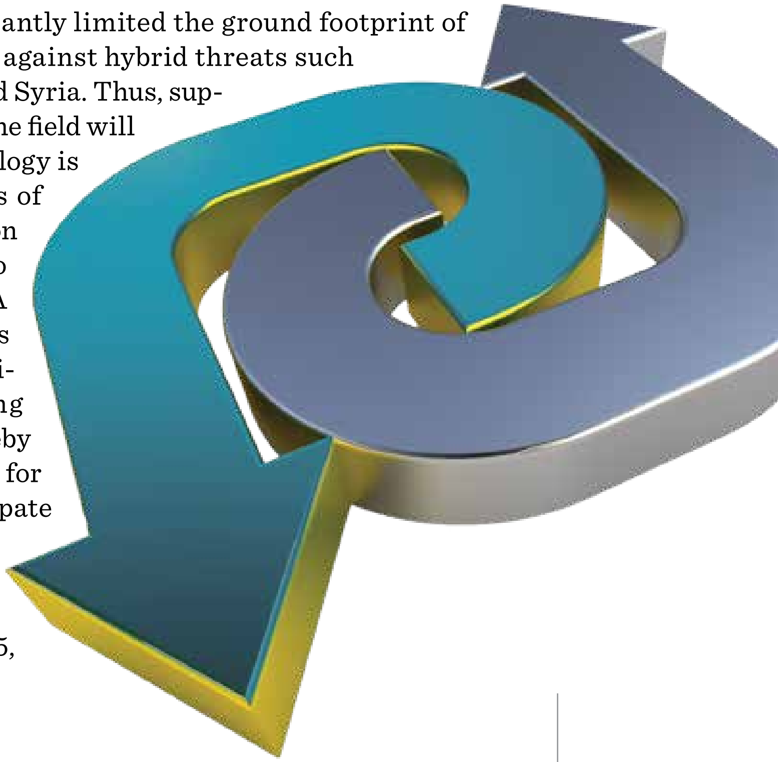
Note. KSA = key system attribute; KPP = key performance parameter; MMBCF = Mean Miles Between Critical Failure; OPTEMPO = operations tempo; ORR = Operational Readiness Rate (Alfieri & McKeon, 2008, p. 55; Department of Defense, 2010, p. 11).

Stryker Supportability Conclusions

Based upon Figure 3's highest relative weight of 52.70%, the recommended priority of effort is to maximize the availability of adaptive combat vehicle systems during deployments that are longer than the original requirement. Likewise, an availability improvement strategy must seek to reduce costs. Since CLS and its higher sustainment costs usually accompany the introduction of new technology into an adaptive baseline, a viable plan for maximizing availability and reducing costs would involve an early design effort for replacing contractor maintenance with soldier mechanics and developing a more robust force structure to manage the Stryker maintenance supply chain better.

After the initial Stryker vehicle deployment to Iraq ended in 2004, the U.S. Army commenced plans to expand significantly Stryker Brigade Combat Team sustainment force structure, including increased soldier mechanic personnel and the activation of forward support companies in each brigade's maneuver battalion (Department of the Army, 2014, pp. 1-10 and C-1; Government Accountability Office, 2006). In hindsight, the use of a decision matrix and heuristics developed from the initial Iraq maintenance reports could have assisted an earlier and similar decision cycle for improving sustainment and supportability of the deployed Stryker vehicle fleet.

President Obama has significantly limited the ground footprint of U.S. military forces deployed against hybrid threats such as the Islamic State of Iraq and Syria. Thus, supportability data collection in the field will be constrained as new technology is provided to smaller numbers of U.S. forces and existing weapon system baselines are adapted to counter hybrid threat tactics. A decision matrix using heuristics presents a method for acquisition supportability planning during current conflicts, thereby serving the Army vision need for "enhancing methods to anticipate future demands on our forces and increased investments in research and development" (Department of the Army, 2015, pp. 8–9).



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References

Alfieri, P., & McKeon, D. (2008). Stryker suitability challenges in a complex threat environment. *Defense Acquisition Review Journal, 15*(1), 48–63. Retrieved from http://www.dau.mil/pubscats/PubsCats/ARJ47_Alfieri.pdf

Deiter, G. E., & Schmidt, L. C. (2009). *Engineering design* (4th ed.). New York, NY: McGraw-Hill.

Department of Defense. (2010, December). *Selected acquisition report: Stryker.* Retrieved from http://www.dod.mil/pubs/foi/Reading_Room/Selected_Acquisition_Reports/STRYKER-SAR-25_DEC_2010.pdf

Department of the Army. (2014, April). Brigade support battalion. *Army Techniques Publication No. 4-90*. Washington, DC: Author.

Department of the Army. (2015). *The Army vision: Strategic advantage in a complex world.* Retrieved from http://www.army.mil/e2/rv5_downloads/info/references/the_army_vision.pdf

Government Accountability Office. (2006, September). *Defense logistics: Changes to Stryker vehicle maintenance support should identify strategies for addressing implementation challenges* (GAO-06-928R). Retrieved from http://www.gao.gov/assets/100/94423.pdf

Wasek, J. S. (2005). *Mapping system capabilities to requirements and performance metrics for capabilities-based acquisitions: DoD applications* [Doctoral dissertation draft]. The George Washington University.

Biography

Dr. Samuel H. Amber recently completed a 2016 Congressional Fellowship in the U.S. Senate. Dr. Amber was a field artillery officer for 7 years followed by 3 years of program management activities with the U.S. Army's Tactical Exploitation of National Capabilities program. He holds a PhD in Systems Engineering from The George Washington University.

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